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Illuminating Lesser Garth Cave, Cardiff: the human remains and post-Roman archaeology in context

By RICHARD MADGWICK,[1] MARK REDKNAP[2] and BRIAN DAVIES[3]

During a series of relatively poorly documented excavations carried out during 1912–14 and 1963–64 human bone was recovered from Lesser Garth Cave near Cardiff. Published reports of the cave investigations focused on the artefactual evidence, and the wide range of possible dates and interpretations concerning the human bones have failed to provide a reliable basis for understanding the significance of the remains within the cave's biography. This paper presents new scientific evidence regarding the human remains including findings from full osteological analysis, targeted carbon, nitrogen, oxygen and strontium isotope analysis and a programme of radiocarbon dating. Analysis records seven individuals, with a minimum of five if the fifty-year excavation gap is ignored. The radiocarbon dates suggest intermittent human presence in the cave from the post-Roman to the post-medieval periods. The paper also offers a reappraisal of post-Roman artefacts, and re-assessment of this site in the context of the diverse ways in which caves are now understood to have been used during this period.

ARCHAEOLOGICAL AND TOPOGRAPHICAL INTRODUCTION

Lesser Garth Cave, Radyr and Morganstown, Cardiff (ST 1255 8210), is an unscheduled site 'situated about 120m above Ordnance Datum, on the south-east corner of the heavily wooded Lesser Garth hill, overlooking the Taff gorge to the east. The entrance, which faces south on a steep rocky slope, is 2m wide and 0.8m high, and is partly blocked by fallen boulders. The cave then opens into a curving sequence of chambers and passages, all about 4m wide, which form the first 30m of a complex system penetrating deep into the hillside' (RCAHMW 1976, 19–20; Figs 1, 2). The crown of the hill has been a source of iron ore from, perhaps, as early as the Roman period (Tim Young, *in litt*.), until the 1920s. From 1921, the high quality dolomite deposits (now known as the Pembroke Limestone Formation) have been increasingly exploited (Thomas 2014, 181) and immediately to the north of the cave now lies the large Taffs Well Quarry. In 1965 quarrying revealed an Iron Age hoard in the same area of the hill as the cave (Savory 1976, 63–4, figs 8, 37; Fig. 2);[4] a Bronze Age South Wales type socketed axe has also been found (Savory 1980, 110).[5] The size of the cave entrance today (Fig. 3) is misleading, as it is the result of widening during the M. S. Hussey's excavations. His report states that the original entrance was less than 2ft square (Hussey 1966, 22). Hussey widened the cave entrance in order to remove stone in his search for archaeological material, having noted that the main chamber 'is filled with loosely packed large boulders to a height of 20 ft' (ibid. 18; see Fig. 4 for photograph of interior in 2012). He only stopped excavating when moving the stone became too dangerous.

The cave was excavated sporadically between 1912 and 1914 by the local Lewis family, principally Trevor Lewis. A handwritten report of this work made by John Ward (first Keeper of Archaeology, National Museum of Wales), following his visit to the site on 27 December 1913, noted the presence of 'prehistoric, Roman and post-Roman' objects.[6] In 1920 Mortimer Wheeler carried out further work, and discovered two hearths and Romano-British pottery (Wheeler 1923, 68). This was followed by what were described

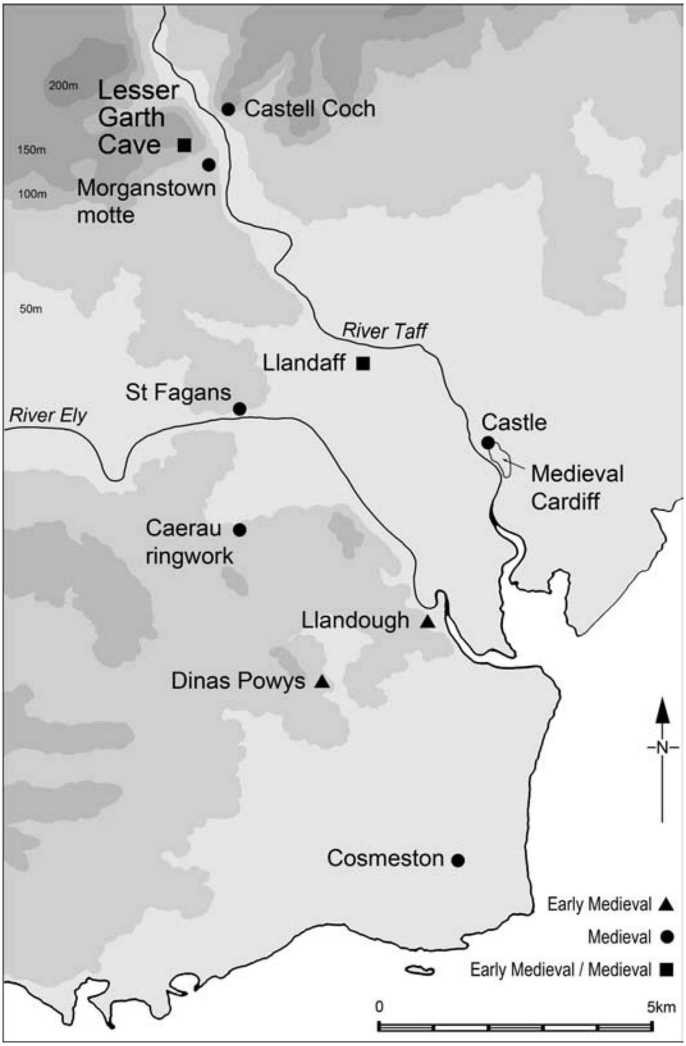

Fig. 1. Location map of Lesser Garth Cave and main early medieval to medieval settlements. © *National Museum Wales*.

as 'Final Excavations' by Hussey, with the support of several south Wales speleological societies, in 1963 and 1964 (Hussey 1966). These excavations produced artefacts ranging in date from the Neolithic to post-medieval.[7] The early medieval finds were studied by Leslie Alcock and subsequently Ewan Campbell, the latter reattributing some artefacts to the Roman period, such as the crucible fragments published by Hussey (Alcock 1959; Campbell 1988, 86–7). Human remains were also recovered in both Trevor Lewis's and Hussey's excavations, the discovery of which are described below. However, in contrast to the artefactual evidence, these have been subject to very little research. Outstanding questions regarding the recovered evidence included the date and taphonomy of the human remains, and whether any association with the material culture from the cave could be established. As the skeletal material had not previously undergone full osteological analysis, basic demographic information such as the number of individuals, their age, sex, health and stature remained unknown. The programme of research reported on here aims to address these questions.

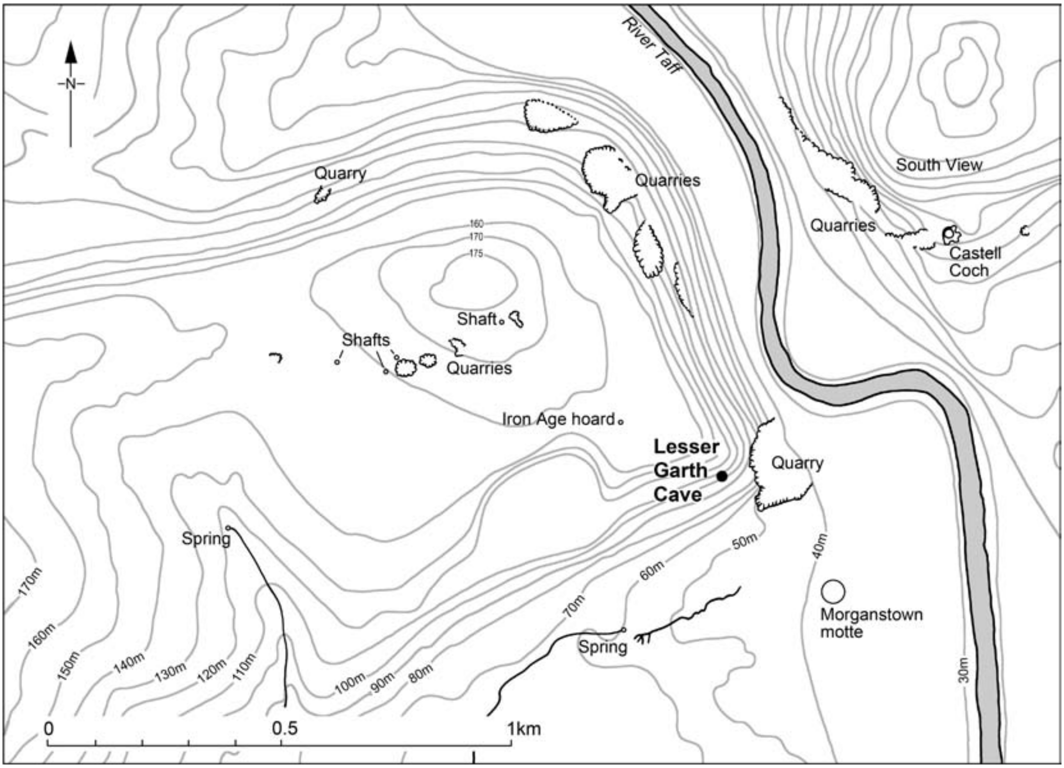

Fig. 2. Topography of Lesser Garth about 1970, showing early quarry pits and the summit, which no longer exists. © *National Museum Wales.*

Fig. 3.
The authors entering the cave mouth in 2012.
© *National Museum Wales*.

Fig. 4.
View of cave interior near the mouth, during visit in 2012. © *National Museum Wales*.

THE DISCOVERY OF HUMAN REMAINS

Burials within caves have long been recognised as a common phenomenon in prehistory, and wide date ranges have been suggested for the human remains from the cave.

John Ward described the human remains as being 'found in one of the lower spaces or vacuities amongst the smaller rock rubbish which half chokes it, and evidently came from a higher level – from, in fact, a small level space near the entrance, & from which the various objects – prehistoric, Roman & post-Roman – were obtained which are now in the Museum'.[8] In the absence of independent dating for the human remains received (individuals 4–7 in this report), he offers one possible interpretation: 'one is

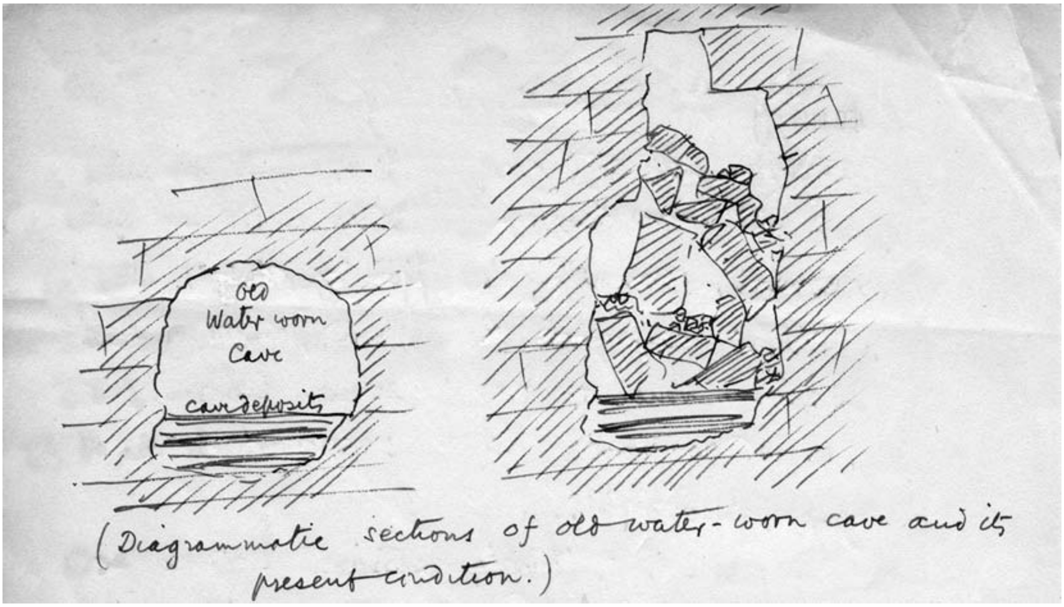

Fig. 5. Diagrammatic sections by Ward of the cave: on left, as it may once have looked; on right, condition in 1913. © *National Museum Wales*.

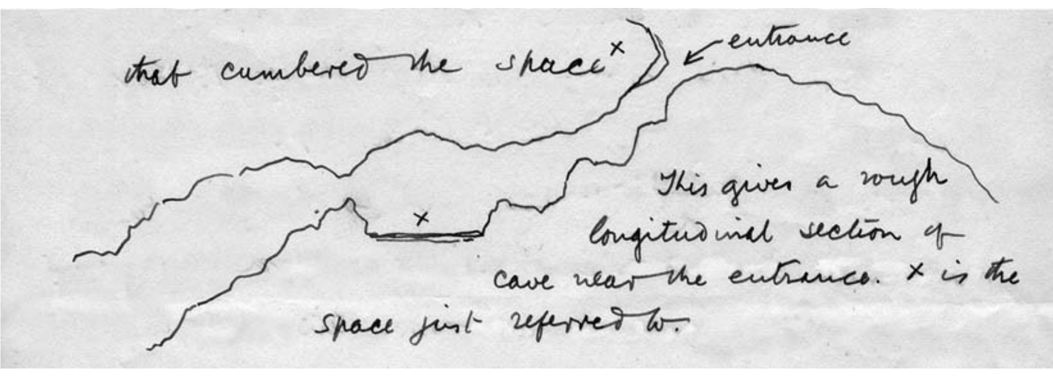

Fig. 6. Sketch by Ward made in 1913 in which he 'gives a rough longitudinal section of cave near the entrance. X is the space where human remains were found'. © *National Museum Wales*.

tempted to conjecture that the cave was used as a prehistoric burial chamber, and that in later times when the cave was resorted to for other purposes, the skeletons were thrown down the adjacent chasm with much portable stone that cumbered the space'. He marks the space referred to on a longitudinal section through the cave (Figs 5, 6). He described the entrance as 'inconspicuous and cramped', 'and could easily

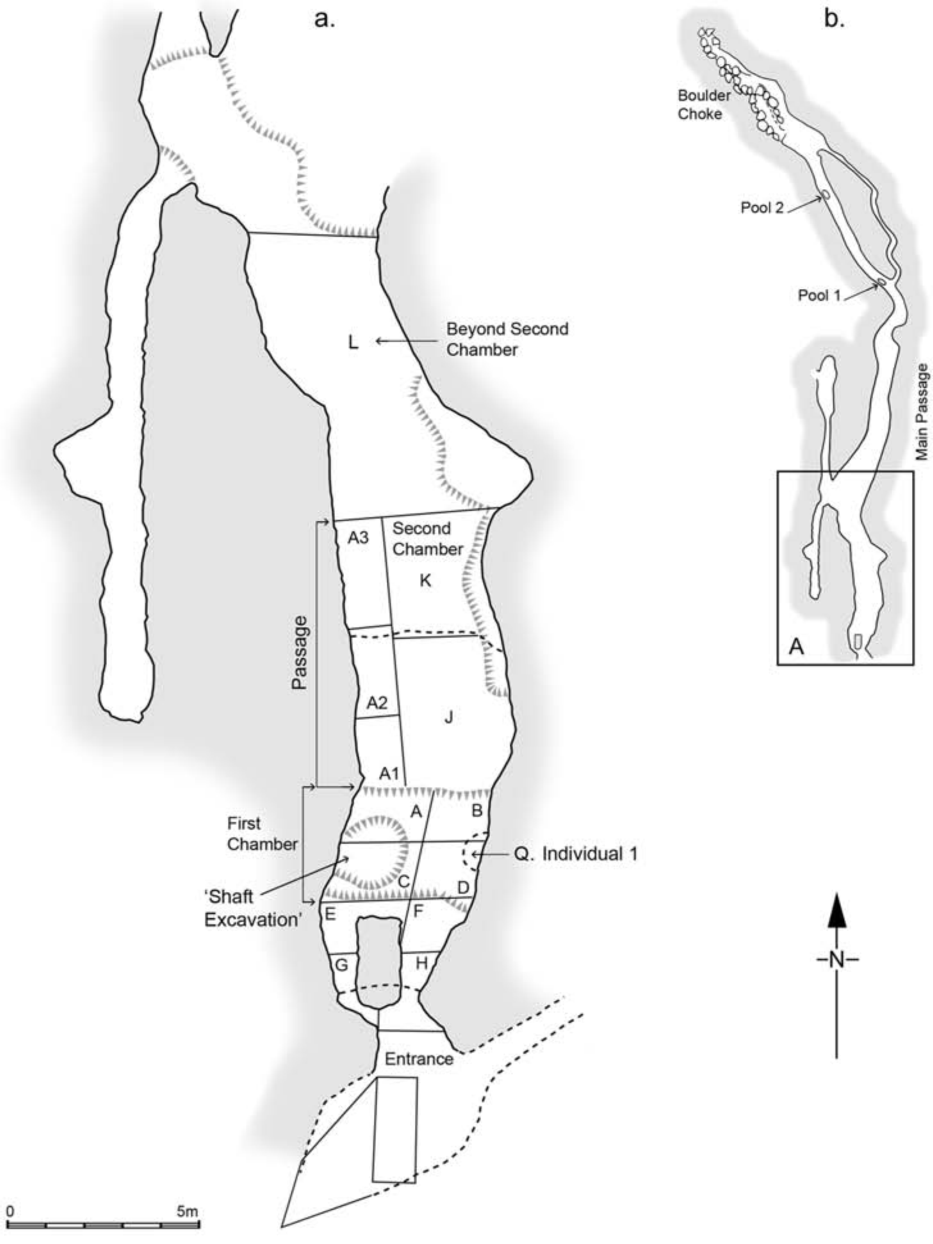

Fig. 7. Plan of the cave system, and Hussey's subdivision of the front zone, based on the plan published in *Transactions of the Cardiff Naturalists' Society*. © National Museum Wales.

be walled up, and thus convert the cave into a burial chamber of the type in vogue during Neolithic times. . . . Large portions of several human skulls have been found'.

Hussey also recovered human remains in the 1960s (individuals 1–3 in this report). He had divided the cave into zones, gridded by letter ('Entrance and First Chamber', A–H; 'Passage between 1st and 2nd Chambers', J, A1–3; 'Second Chamber', K; 'Beyond the Second Chamber', L; 'The Shaft excavation', A and C). He concurred with the earlier view that the cave could have been used for late Neolithic or Early Bronze Age burial as well as habitation (Hussey 1966, 32–3), and that the human remains found 'beneath the floor' of the first chamber 'probably' belonged to the Romano-British period—although he acknowledged that the discovery of medieval pottery *below* the bones suggested that the burial could be 'later than the twelfth century' (ibid. 33–4; Figs 7, 8).

The Royal Commission's inventory entry acknowledged that 'some at least of the disturbed skeletal material was post-bronze-age in date' but in the absence of further independent dating evidence reiterated Hussey's view that Neolithic and Bronze Age burials appeared to have been cleared and 'some of the human remains . . . must be roughly contemporary with the domestic occupation there' (RCAHMW 1976, 14–15). However, it was noted that 'There is a further possibility that the human remains are all of Romano-British date, since cremation is the rite normally to be expected in a middle-bronze-age context. *Cf* Culver Hole, Llangenith' (RCAHMW 1976, 21, n. 4).

The human remains were relatively heavily fragmented and were recovered in a largely disarticulated state. Consequently, even identifying the number of interred individuals was a complex task. Analysis demonstrated that a minimum of five individuals were identified with certainty but, based on excavation history, size and morphology, it is likely that at least seven individuals were represented. A brief interim statement concerning research on the cave was previously published (Redknap *et al.* 2008). This paper presents a more comprehensive account of results from analysis of the human bone and the programme of radiocarbon dating of five individuals. The radiocarbon dating programme provided surprisingly wide-ranging dates, none of which overlapped. Dates ranged from the early medieval to the post-medieval period. Pilot programmes of isotope analysis demonstrated that two individuals were consistent with having been raised in south Wales and all had consumed a principally terrestrially-derived diet. This research was instigated and funded by Cardiff Archaeology Society who acted as collaborators throughout the project.

Fig. 8.
Area B photographed during the Hussey excavation, showing the character of the deposits encountered. © *National Museum Wales*.

Fig. 9.
Shaft 'Q' in the cave interior in 2012. © *National Museum Wales*.

Location of the human remains

John Ward in his note of 28 December 1913 refers to the Lewis family ‘excavating (or rather ‘grubbing’). During their several days work, they found scattered human bones’. Individuals 4, 5, 6 and 7 were recovered in these excavations. Individual 6 has a moderate level of completeness and individual 7 is the most complete recovered at this time. Ward’s report shows that the human remains were relatively accessible, and his reference to Neolithic burial practice above implies he thought the remains were originally on the floor of the cave. In the circumstances it seems reasonable to assume that individuals 6 and 7 were originally laid on the cave floor or lodged directly into the ‘chasm’ i.e. they were not buried under the floor. The limited number of bones representing individuals 4 and 5 (three each) makes consideration of their original resting place impracticable.

Hussey’s report shows that the remains of individual 1 (the most complete individual found in the excavation) were revealed by a rock fall during excavation 20ft below floor level (marked ‘Q’ in Fig. 7; see also Fig. 9). He further notes that this material ‘came from a shaft of 6ft diameter between the boulders’. A label states that it came ‘from the bottom of shaft through roof collapse’. He does not suggest that the ‘roof’ reached floor level and, in his ‘Discussion’ section, refers to ‘The human bones found beneath the floor of the first chamber’. We also know that the floor itself has been subject to considerable excavation. On the basis of Hussey’s description, it appears reasonable to assume that individual 1 was deliberately buried beneath the floor. This is the only report of the finding of human remains by Hussey. As individuals 2 and 3 (consisting of one bone each) were also found by Hussey, these might also have been recovered from the same rock fall. If true, the remains of individuals 2 and 3 could also be buried under the floor of the first chamber (Fig. 5, A, B, C, D).

MATERIAL CULTURE FROM THE CAVE

Post-depositional movement of material within the cave along with rock falls, and the unknown impact of animal activity on cave stratigraphy mean that the precise relationship between the human remains and artefact horizons is poorly understood, particularly as it was thought possible that some items may have been washed in. None of the artefacts were reported to be reliably associated with the human bones recovered from the cave, although the presence of green staining on some bones points to the proximity of copper alloy artefacts at some point in their taphonomic history.

The artefactual assemblage from the cave spans the Neolithic to the post-medieval periods (Hussey 1964–66, 25–32; Alcock 1959, 221–7; Campbell 1988, 86; Branigan and Dearne 1991, 158–9), but is worth reviewing in order to contextualize activities in the cave that may have a bearing on the subject of this paper. The prehistoric material recovered during Hussey’s excavations included Early Bronze Age worked flint, Middle Bronze Age pottery relating to the Biconical Urn, Deverel-Rimbury and Trevisker traditions (including fragments of bucket and barrel urns and a devolved collared urn, dated 1500–1150 BC; Savory 1980, 159–60; A. Gwilt, *in litt*.). Roman finds include one Early Roman necked jar, third-century Roman coarseware and hobnails from shoes. Evidence for non-ferrous metalworking appears to be Late Roman, comprising crucibles with residues of silver and copper,[9] a fragment of copper alloy casting waste,[10] two unfinished hammered squares of copper alloy of similar dimensions,[11] a large hammered semi-manufactured strip of low grade silver,[12] two rectangular offcuts of copper alloy sheet with high quality gilding on one face,[13] and a multiple-lobed copper alloy mount with similar high quality gilding, perforated in the final lobe for a rivet with gilt domed head, similar to a mount with knobs and collars from the Roman amphitheatre at Caerleon (Chapman 2005, 127, SR 25). These have suggested the recycling of impure silver in the cave, while no evidence for iron working in the cave has been identified.

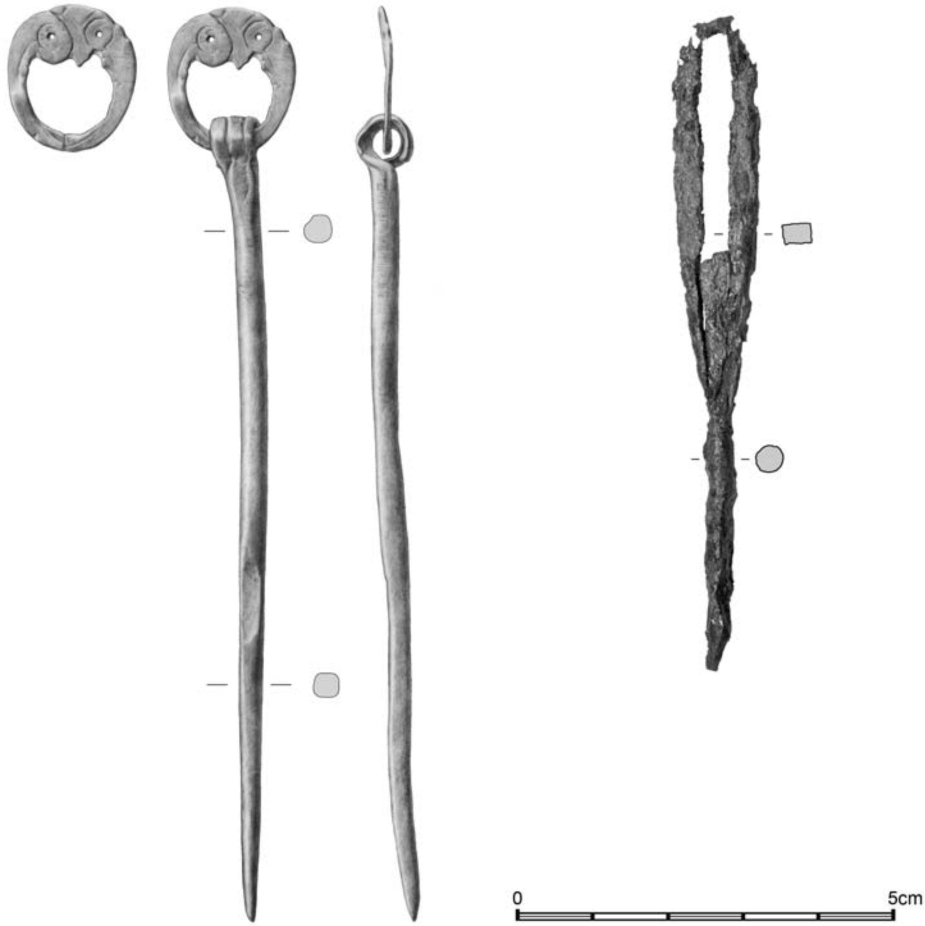

Fig. 10. *Left*: the brooch pin from Lesser Garth Cave. *Right*: the 'slotted pointed tool' from Lesser Garth Cave. © *National Museum Wales*.

What Hussey described as a 'forge' appears to have been a small hearth, and the 'clinker' was re-identified as slightly burnt cave breccia (Campbell 1988, 86). Suggestions of an illicit activity in the third century have been compared to the counterfeiting evidence from Coygan Camp (counterfeiter's coin hoard; Boon 1967, 116–24) and the mine passages at Draethen (third-century coins and pottery; Boon 1972).

Early medieval metalwork included two items that deserve further consideration: what Alcock described as a 'loose-ring pin of bronze', attributed to the seventh century (Fig. 10, left)[14] and an iron slotted pointed tool (Alcock 1959, 221–2; Fig. 10, right).[15]

Brooch-pin (Fig. 10, left)

Small brooches with very long pins are often inaccurately classified as 'ring-pins' or 'ring-headed pins'. In these, the pin is fitted with a loose ring or hoop of pseudo-penannular form, often embellished with enamelling, interlace or zoomorphic ornament. Examples from Ireland include Lagore (Hencken 1950, fig. 19, no. 575; Eogan 1991, no. 94), while examples have been found within Insular material on Viking graves in Norway such as Koltjøn, Skafså parish, Tel. and Valheim, Ådal parish, Rogaland (Petersen 1940, 197, fig. 159; 200, fig. 162). Fanning considered these 'distant cousins' of the ringed pin series, their form being derived from that of pseudo-penannular brooches of the Tara type, and best treated in parallel with the brooches of this type (Fanning 1994, 5). None were recorded by Fanning from any of the Dublin settlement sites, though there are some old finds from the vicinity of the Kilmainham/Islandbridge cemeteries (Harrison and Ó Floinn 2014, 148–153). Fanning considered the form to be in vogue during the second half of the eighth and early ninth centuries, and preferred the term 'ring-brooch', though Youngs (1989) and Harrison and Ó Floinn (ibid. 1480) adopted the term 'brooch-pin', which is adopted here. In his report on the Lesser Garth example, Alcock (1959, 222) drew attention to a number of Irish examples, in particular those with small penannular heads from Lagore, Co. Meath, and Cahercommaun, Co. Clare.

The Lesser Garth brooch-pin was found in 1912/13, presumably from the 'small level space near the entrance' of the cave described by Ward, who recognized it as post-Roman, and considered it to be of 'Irish origin'. According to Ward's list of objects made on 3 April 1913, it was 'partly covered with stalagmite, a portion of which adheres'. The upper shaft of the loop-headed pin has a circular cross-section, and the pin has a maximum overall length of 107mm. The 'ring' differs from the cast rings of ringed pins in being cut out of sheet copper alloy, and engraved with incised arcs to demarcate miniature pseudo-penannular brooch terminals, which are decorated with incised circles around perforations, imitating the collets for beads found on the terminals of the full-size brooches it is copying (creating ring and dot motifs). This 'ring-brooch' element contrasts in character with the solidly cast pin, which has a wrap-around head decorated with two longitudinal grooves in line with the shaft, and an internal loop diameter of 5mm. Slight distortions of the pin shaft, which has been hammered to a square cross-section lower down the shaft, suggest that the pin is a modified penannular brooch pin. The dimensions and form are similar to those of an incomplete penannular brooch pin from the amphitheatre excavations at Caerleon (Redknap 1991, 32, bottom right).[16] On the Lesser Garth shaft there are vestigial traces of the rise and fall of the pin over the brooch hoop, suggesting that the original brooch of which it once formed part had an inner diameter of about 55mm. This compares to 42mm for the external diameter of the Longbury Bank penannular brooch and 51mm for the hoop of the silver Newton Moor brooch, and with the head style suggest manufacture for a 'British' penannular brooch in the late seventh or eighth century. The alloy composition of Lesser Garth shaft is 88.6% copper, 5.73% tin, 0.2% silver and 0.06% zinc, similar to the compositions of the Twlc Point pin,[17] and the Pant-y-saer and Culver Hole brooches.[18] While the 'ring-brooch' element appears to imitate more elaborate cast examples such as one from the river Shannon at Killaloe, Co. Clare, attributed to the ninth century (Youngs 1989, cat. no. 95), the above points suggest the brooch-pin conversion within Wales as plausible. Fanning's dating and such stylistic affinities suggest a late eighth- to early ninth-century date for the pin modification. Their rarity in Viking graves in Ireland, Britain and Scandinavia support the inference that they were already going out of fashion by the mid-ninth century (Harrison and Ó Floinn 2014, 152). Loop-headed ringed pins also occur in some Anglo-Saxon contexts, for example, from Hamwic (Hinton's type G), but they are often of less solid construction than many western British examples, some having wire loops. The cemetery at Winnall II produced two worn as a pair (Meaney and Hawkes 1970, fig. 9, grave 8; Hinton 1996, 32). One was compared with seventh- to ninth-century Irish ringed pins, and Hinton suggested that it might be evidence for an Irish merchant passing through Hamwic (no. 31/883; Hinton 1996, 32, fig. 13). There is no particular reason to suggest that the Lesser Garth modification required a skilled Irish craftsman or similar ownership, and the lack of finesse in the manufacture argues against this possibility. The practice of recycling brooch elements is well illustrated by the brooch terminal from Llys Awel Farm, Pencorddyn-mawr, north-east Wales (Lewis 1982, 151–4, pl. 5).

Slotted pointed tool (Fig. 10, right)

The other item Alcock drew attention to was the iron slotted pointed tool, comprising a small bar folded to create a flattened longitudinal slot, the ends of the bar being forge-welded together at one end to the sides of a short point or spike. It was recovered from an unknown area of the cave in 1912. Alcock took this discovery with the evidence of the pin to signify Irish influences in early medieval Wales. *Contra* early claims for an Irish origin for such tools, their wide distribution indicates that they are not culture specific. They occur in Irish, Scottish, British and Pictish areas of settlement of pre-Norse date (generally dated to between the seventh and tenth centuries), and occasionally in Anglo-Saxon contexts. One has been found at the tightly dated early medieval Llangorse crannog (late ninth to early tenth century; Redknap forthcoming), and Irish occurrences include two from Lagore crannog (Hencken 1950, 118), seven unstratified examples from Cahercommaun (Cotter 1999, 71), and one recently discovered in a context thought to be ninth century at Dun Eoghanachta, Aran Islands (Cotter 1999, 71). Similar objects, sometimes being called 'spatulate tools', have also been reported from Anglo-Saxon contexts at sites such as North Elmham (Goodall 1980, 513, fig. 266, no. 48) and Flixborough (Ottaway 2009, 218; fig. 20, nos 9, 10). An example from Thwing appears to lack slots, but has relief groove and dot decoration (Ottaway 2009, 218).

A variety of functions have been proposed for these slotted objects, which occur in multiples on settlement sites. These include the riveting or joining of strips of metal (Campbell 1998, 162), instruments for boring (Ó Ríordain 1949, 79), as fire-steels (Geake 1997, 93). Ottaway rejected the idea that the points would work satisfactorily as tangs for handles, and suggested that some of these tools were 'intended to be gripped with the 'blade', while the 'tang' was used as a pointed tool' (Ottaway 2009, 218). Hencken's original suggestion that they could have been associated with sewing or the making of some coarse cloth or material such as rush matting (Hencken 1938, 53), is one attractive proposition, and their function as a specialist craft tool seems likely.

HUMAN BONE

Human bone was recovered during both the Lewis and Hussey excavations (1912–14 and 1963–64 respectively). In total the assemblage comprised 221 human and animal bone fragments, not all of which could be identified to element. These remains were subject to full osteological analysis at Amgueddfa Cymru – National Museum Wales, Cardiff. The principal aims of analysis were to reveal the minimum number of individuals present, to reconstruct the completeness, fragmentation and, where possible, taphonomic histories of discrete individuals. In addition, analysis sought to reconstruct the demographics of the sample and provide recommendations for a limited programme of radiocarbon dating. Radiocarbon dates are reported here for five individuals. Analysis was undertaken by the ^{14}Chrono Centre at Queen's University, Belfast. A pilot isotope study was also undertaken on two of the dated individuals in order to establish whether individuals of non-local origin could be identified, given the recovery of artefacts such as the brooch-pin, although it has long been recognised that Irish parallels for this and other items 'need not mean that the inhabitants of Lesser Garth cave were Irish' (Knight 1984, 345). ^{87}Sr/^{86}Sr and δ^{18}O isotope analysis was undertaken on dental enamel from two individuals (6 and 7) that were of early medieval date at the NERC Isotope Geosciences Laboratory, British Geological Survey, Keyworth.

Methods

Osteological analysis

Osteological analysis was undertaken at Amgueddfa Cymru – National Museum Wales by Richard Madgwick. Age at death was determined based on dental eruption and attrition (Brothwell 1981; Smith

1991), pubic symphesis morphology (Brooks and Suchey 1990), auricular surface morphology (Lovejoy *et al.* 1985) and epiphyseal fusion data (Scheuer and Black 2000). Supporting evidence was provided by cranial suture closure (Perizonius 1984). Sex assessments were undertaken using morphology of the mandible, skull and pelvis following the criteria of Buikstra and Ubelaker (1994). Stature was calculated using the formulae of Trotter and Gleser (1952; 1958; 1977). Dental calculus and cribra orbitalia were identified and scored according to Buikstra and Ubelaker (1994, 56, 151) and enamel hypoplasia was identified and recorded using the methods of Mays (1998, 157) and Buikstra and Ubelaker (1994, 56).

Radiocarbon dating

Radiocarbon dating was undertaken on five individuals. These comprise individuals 1, 6 and 7, which were the most complete, individual 5 (a juvenile) and individual 3, which was represented by a proximal humerus. Extracted collagen was AMS dated using standard ^{14}Chrono Centre protocol. Dates were calibrated using CALIB Rev. 7.0.0 (in conjunction with Stuiver and Reimer 1993) using calibration datasets from Reimer *et al.* (2013).

Isotope analysis

Carbon and nitrogen isotope analysis was undertaken on the five dated skeletons, as part of the radiocarbon dating programme. Carbon and nitrogen isotope analysis represents a long-established method for dietary reconstruction in past populations. The biochemical basis of the approach has been explained in detail on numerous occasions (e.g. Ambrose 1993; Katzenberg 2000) and therefore the premises behind the approach are only briefly described here. The relative abundance of the stable carbon isotopes of ^{13}C and ^{12}C (expressed as δ^{13}C in parts per mil—‰ or parts per thousand), is dictated by many variables, but in dietary studies in temperate Europe, differences between terrestrial and marine ecosystems are most important. Marine ecosystems are enriched in ^{13}C and therefore humans with substantial marine components in their diets will have higher δ^{13}C values than those with terrestrially-derived diets. Variation in nitrogen stable isotope ratios (^{15}N to ^{14}N, expressed as δ^{15}N) also has a very diverse aetiology. A major cause of variation is systematic changes as organic matter is transferred up the food chain (i.e. from plants to herbivores and from herbivores to carnivores). This trophic level shift means analysis is useful for assessing the contribution of animal protein in diets and also the degree of marine input in feeding (due to elongated food chains in marine ecosystems).

δ^{13}C/δ^{15}N isotope ratios of sample collagen were measured on a Thermo Delta V elemental analyser—isotope ratio mass spectrometer (EA-IRMS). Three blanks are measured at the start of the run followed by three standards of Nicotinamide (known values of 59.01 %C and 22.94 %N) for the % element values. The samples are run in duplicate. Standards used for stable isotope analysis of collagen for δ^{13}C and δ^{15}N are IA-R041 L-Alanine (δ^{15}N, –5.56±0.14‰; δ^{13}C, –23.33±0.10‰), IAEA-CH-6 Sucrose (δ^{13}C, –10.449 ± 0.033‰) and IAEA-N-2 Ammonium Sulphate (δ^{15}N, +20.3 ± 0.2‰). An in-house fish bone standard (Fish) is also run for quality control (δ^{13}C, –31.44; δ^{15}N, +17.78; (n >100)). For %C and %N determinations nicotinamide is used (%C, 59.01%; %N, 22.94%). The machine uncertainty is reported for δ^{13}C and δ^{15}N. This has been validated by the observed reproducibility of measurements on 10 replicate aliquots of seven different bone samples, which show no additional variability.

Individuals 6 and 7 were also subject to δ^{18}O and ^{87}Sr/^{86}Sr isotope analysis to establish whether they were raised locally. These individuals were selected because they were dated to the post-Roman/early medieval period, as this was a phase of substantial population movement both within Wales and beyond. The first upper molar was sampled for individual 6 and the first lower molar for individual 7.

Oxygen isotope ratios reflect the character of local meteoric water and variation is generally dictated by geography and climate (see Darling *et al.* 2003). When analysed in dental enamel, which does not remodel through life, they provide a geographic/climatic signal for early life origins. Ratios are generally reported as delta values (δ) in terms of parts per mil (‰ or parts per thousand), which represent the ratio of the heavier isotope (^{18}O) to the lighter isotope (^{16}O) between a sample and a standard.

Isotope analysis of oxygen ($\delta^{18}O$) was undertaken by Hilary Sloane, following NIGL protocol and involved the loading of approximately 3mg of clean, powdered enamel into glass vials, which were then sealed with septa. Vials were transferred to a hot block at 90°C on a Multiprep system (GV Instruments, Manchester, UK) and were evacuated and four drops of anhydrous phosphoric acid added. The resultant CO2 is cryogenically collected for 14 minutes and transferred to a GV IsoPrime dual inlet mass spectrometer. The resultant isotope values are reported as per mil (‰$^{18}O/^{16}O$) normalized to the PDB scale using an in-house carbonate reference material (KCM) calibrated against NBS19 certified reference material. The $\delta^{18}O$ values are then converted into the SMOW scale using the published conversion equation of Coplen (1988).

The analysis of strontium isotope ratios ($^{87}Sr/^{86}Sr$) represents an established approach for reconstructing human migration and identifying non-local individuals in the archaeological record (see Montgomery 2010). The approach relies on the premise that local strontium from the geological region in which an individual draws their food and water enters the body and ultimately skeletal tissues through the food chain, transferred from underlying geology to plants and animals as nutrients. Dental enamel does not remodel through life and therefore analysis provides a biosphere signal relating to early life origins. No local plants have been analysed to define the local range of $^{87}Sr/^{86}Sr$ isotope ratios in the vicinity of the cave. Therefore approximations of expected values are used based on Evans *et al.* (2010).

For $^{87}Sr/^{86}Sr$ isotope ratios, analysis was undertaken by Jane Evans following NIGL protocol. Once drilled, samples were transferred to a clean laboratory and working area (class 100, laminar flow) and were cleaned ultrasonically in high purity water, then rinsed twice, dried down in high purity acetone and weighed into pre-cleaned Teflon beakers. ^{84}Sr tracer solution was added and samples were dissolved in distilled 16M HNO3 (nitric acid). Strontium was collected using Dowex resin columns and loaded onto a single Re Filament with TaF following the method of Birck (1986). Isotope composition and concentrations were determined by Thermal Ionisation Mass Spectroscopy (TIMS) using a Thermo Triton multi-collector mass spectrometer. All strontium ratios have been corrected to a value for the international standard of 0.710250.

Results

The assemblage comprised 209 human bone fragments and 12 faunal specimens that are not reported on here. Many human bone fragments were very small and could not be assigned to an individual. The remains generally exhibited good surface preservation. Post-depositional erosion was relatively frequent but rarely severe. A total of 24 specimens exhibited evidence of water erosion, a common modification that might be expected at a cave site. Weathering was present on 20 fragments, gnawing on five and a further nine were abraded but none of the modification was severe. As preservation is generally good, modification is unlikely to result from intentional sub-aerial exposure prior to final deposition, but rather through taphonomic re-elaboration when bones are disturbed long after deposition.

The primary objectives of analysis were to identify the number of individuals present, the phases during which the cave was used for the deposition of human remains and the completeness and taphonomic histories of the skeletons. Reconstructing discrete individuals from disarticulated material largely devoid of contextual information is a complex task. Without destructive analysis, it is only possible to be sure that different elements belong to the same individual when they can be demonstrated to articulate and even this cannot be taken as definitive evidence. Identifying articulations is often not possible and consequently judgement calls must be made on which elements are likely to derive from the same individual, based on metric and non-metric data, pathological evidence, robusticity and ageing/fusion. Although the following discussion is presented by individual, many elements cannot be assigned with complete confidence, but are attributed on the balance of probability. For the purposes of this report remains from the 1912/13 excavations are considered to represent separate individuals from those excavated in 1964. Hussey's (1966) report suggests that it is unlikely that bones recovered from the 1912–13 excavations were originally commingled with those human remains recovered in 1964, and the limited contextual information available appears to support this view. However, the possibility that remains recovered from both excavations derive from the same individuals cannot be discounted (see discussion below). The 141 assignable human bone fragments represent a minimum of seven individuals. This could be amended to a minimum of five individuals if material from the two phases of excavation are pooled. Only three individuals are complete enough to yield considerable biographical information, although one juvenile comprising only three bones can at least be aged with some precision. The remaining three individuals are represented by only a few fragments and in some cases have been differentiated from other individuals only on the basis of being excavated during different programmes. No cause of death was identifiable on any of the remains. Individuals are numbered following Redknap *et al.* (2008), with individuals 1 to 3 deriving from the 1964 excavations and 4 to 7 from the 1912 excavations. Table 1 provides summary results of osteological analysis, Table 2 provides details of the radiocarbon dates and Table 3 shows the isotope data.

Individual 1 (cal. AD 1250–1300)
Individual 1 is the most complete individual recovered during the 1964 excavations and is represented by thirty fragments. The lower post-crania are considerably better preserved and more complete than the upper limbs. The extremities are poorly represented. Elements include both femora, both tibiae, both fibulae, both os coxae, both ulnae, the right humerus, an incomplete right clavicle, right scapula and sternum, the mandible, five vertebrae, four metatarsals, three metacarpals and phalanges. The surface preservation of bones was generally relatively good but sustained contact with water had caused some cortical flaking and abrasion. One intermediate hand phalanx, probably of the third or fourth finger, exhibits clear copper staining consistent with being buried wearing a copper alloy ring (Fig. 11, left). The

Table 1
Summary results of osteological analysis. LEH= Linear enamel hypoplasia

Individual	Sex	Biological age	Approximate completeness (%)	Notes
1	?male	25–35	70	copper staining, Schmorl's nodes, LEH, healed fracture, possible cut made on tibia
2	?	>16	<5	–
3	?	<25	<5	copper staining
4	?	>15	<5	–
5	?	5–6	<5	–
6	?male	*c.* 25	50	LEH, caries, vastus notches, absent M3s, misaligned healed fracture on radius
7	female	17–25	60	copper staining, caries, healed fracture, septal aperture

Table 2
Results of the radiocarbon dating programme

Individual	Element	UBA no.	NMW acc. no.	Radiocarbon age	Calibrated date (2 sigma)	$F^{14}C$
1	Femur	10639	64.135/24.8	726±26 BP	cal. AD 1250–1300	0.9135±0.003
3	Humerus	25584	64.135/24.17	1109±29 BP	cal. AD 880–1000	0.871±0.0031
5	Tibia	10642	20.359/21.53	264±24 BP	cal. AD 1625–1670	0.9676±0.0029
6	Tibia	10640	20.359/21.51	1572±24 BP	cal. AD 425–545	0.8222±0.0025
7	Tibia	10641	20.359/21.52	1435±29 BP	cal. AD 570–655	0.84±0.0031

Table 3
Isotope results. Daux drinking water corrected values represent the mean of equations 4 and 6 (Daux *et al*. 2008)

Individual	UBA no.	NMW acc. no.	$\delta^{13}C$	$\delta^{15}N$	C:N	$^{87}Sr/^{86}Sr$ ratio	Sr concent-ration	$\delta^{18}O$	$^{18}O_{DW}$(Daux)
1	10639	64.135/ 24.8	-21.11	8.77	3.3	–	–	–	–
3	25584	64.135/ 24.17	-20.60	8.60	3.3	–	–	–	–
5	10642	20.359/ 21.53	-20.20	10.82	3.3	–	–	–	–
6	10640	20.359/ 21.51	-21.02	10.79	3.3	0.7109	59.6	26.9	-5.9
7	10641	20.359/ 21.52	-20.23	11.00	3.3	0.7120	67.9	26.8	-6.1

left tibia exhibited a possible cut mark on the lateral surface of the diaphysis (Fig. 12, top). The aetiology of this modification cannot be confidently determined with low power microscopy, although the relative completeness of the elements suggests that it is unlikely to be evidence of flesh removal.

Although precise age determination is hampered by the incompleteness of the skeleton, particularly the cranium, several ageing techniques could still be utilised. Analysis of the auricular surface and pubic symphesis of both pelves indicated an age between 25 and 32 years old. Dental evidence was in accordance, with wear being only moderate, consistent with an age range of 25 to 35. Epiphyseal fusion evidence provides very limited resolution but is in broad agreement, indicating that the individual was over 17 years old at death. Sex determination was also hampered by the absence of the cranium and was more ambiguous than ageing evidence. The pelvis displayed traits typical of both males (morphology of the preauricular sulcus) and females (morphology of the subpubic concavity). However, the pronounced mental eminence and gonial flaring provide strong evidence that the individual was male, consistent with the general robusticity of the postcrania. Using measurements from the femur and tibia, the stature of the individual was calculated as 165–171cm (5ft 4in–5ft 6in).

Pathological alterations to the skeleton were scarce. The mandibular teeth were in good condition with only slight evidence of periodontal disease and calculus. Linear enamel hypoplasia, suggesting periods of

Fig. 11. *Left*: green staining on phalanx from individual 1, from palmar (a) and dorsal (b) aspects. *Right*: pathology on the distal radius of individual 6 probably resulting from a poorly healed misaligned fracture, from anterior (a), lateral (b), medial (c) and posterior (d) aspects. © *National Museum Wales*.

stress during childhood, was evident on four teeth: both first premolars, a canine and a second premolar. All teeth were affected by a single linear lesion except for the left first premolar which exhibited two. Potential causes are wide ranging but can include malnutrition and infectious disease. The presence of two lesions on a single tooth indicates two periods of stress during the developmental years. The locations suggest these occurred around the ages of 3 years and 5 to 6 years.

Degenerative disorders on the postcrania included small Schmorl's nodes on the inferior surface of two vertebrae. This pathological modification is relatively common and represents general degradation of the skeleton. Although it is more common in older individuals, it has a strong genetic component and can also occur in young individuals. The condition either results from herniation of the cartilaginous endplate into the vertebral body or from necrosis due to loss of blood supply under the endplate (Peng *et al.* 2003). In older individuals it tends to relate to the degeneration of cartilaginous endplates, whilst in younger individuals it relates to defects or fractures in the endplates. It is therefore not necessarily indicative of an active life and tells us little more than that the individual is likely to have suffered from back pain. Minor exostosis was observed on the radial notch of both ulnae. The aetiology of this lesion is unknown, but it may result from minor osteoarthritis around the elbow. The only other pathological alteration that was observed was a healed fracture on the left fifth metacarpal (the part of the hand adjoining the little finger). This individual was dated to the medieval period (cal. AD 1200–1300, 2 sigma).

In summary, individual 1 is a young adult, likely male of medium robusticity, who probably died between the age of 25 and 32. The copper stained hand phalanx is strongly suggestive of burial with some form of copper alloy finger-ring. The presence of enamel hypoplasia demonstrates that the individual endured periods of stress during childhood and therefore may have been malnourished or suffered from infectious disease as a child.

Individual 2 (not dated)

Individual 2 derives from the 1964 excavations and is represented by a single poorly preserved, proximal humerus from a gracile individual. Sex cannot be assigned but the complete fusion of the humeral head indicated that the individual was at least 15 years old at death.

Fig. 12. *Top*: possible cut mark on the lateral surface of the diaphysis of the left tibia of individual 1, from posterior (a) and lateral (b) aspects and a detailed inset of the lateral view (c). *Bottom*: green staining on the distal end of the ulna of individual 7, from posterior (a), anterior (b) and medial (c) aspects. © *National Museum Wales*.

Individual 3 (cal. AD 880–1000)

Individual 3 (from the 1964 excavations) is also represented by a single proximal humerus, but this specimen is larger, unfused and morphologically distinct from that of individual 2. The specimen derives from an individual of less than 25 years old. It is stained a bright green colour, indicating that a copper alloy object was present in the matrix, but need not necessarily have been deposited with this individual. A radiocarbon date was published for this individual in Redknap *et al.* (2008) but atypical stable isotope values led to the specimen being subject to repeat radiocarbon analysis in 2014. The re-analysis provided reliable results with a consistent isotope signature. The individual was re-dated to cal. AD 880–1000 (2 sigma), and the previously published date is considered erroneous.

Individual 4 (not dated)

Individual 4 was recovered during the 1912–13 excavations and comprises just three bones: tibia and femur fragments and a complete calcaneus. This skeleton was gracile and was from an individual of at least 16 years of age, based on fusion evidence. Sex determination was not possible. On the balance of probability these elements have been grouped together as deriving from the same individual, although it is possible that the five fragments listed in the descriptions of individuals 2, 3 and 4 could represent five different individuals.

Individual 5 (cal. AD 1625–1670)

Individual 5 was recovered during the 1912–13 excavations and comprises three bones: a thoracic vertebra, a tibia and a calcaneus. All three are exceptionally well preserved considering that they are porous juvenile elements. All are complete or nearly complete (except for unfused epiphyses) and exhibit good surface preservation. Age can be assigned with relative precision, as the centrum of the thoracic vertebra is in the process of fusing to the neural arch. This places the individual in the age range of 5 to 6 years old. Radiocarbon dating of this individual provided a post-medieval date (cal. AD 1625–1670, 2 sigma).

Individual 6 (cal. AD 425–545)

Individual 6 was recovered during the 1912 excavations and exhibits a moderate level of completeness with 42 bones represented and the lower limbs being best preserved. Skeletal remains comprise both humeri, femora, tibiae, fibulae, patellae, tali and maxillae and the frontal, atlas and axis. Also a single zygomatic, scapula, radius, ulna, ischium, navicular, cuboid and calcaneus were recovered. Several metacarpals and metatarsals were also present. In general, the skeletal remains suffered from a moderate degree of fragmentation and post-depositional erosion and only two of the long bones were complete. Two elements exhibited slight evidence of gnawing with a further three instances of weathering and water erosion having been recorded, demonstrating the complex taphonomic history that the remains had undergone.

Patterns of dental attrition are on the borderline of those typical for 17 to 25 year olds and 25 to 35 year olds, suggesting that the individual died close to the age of 25. Epiphyseal fusion can only establish that this individual was older than 16. Sex determination relied on the skull, as the pelvis was all but absent. The pronounced mastoid process is classically male and the glabella also exhibits male characteristics. Parietal eminences and the right zygomatic are also very robust, providing further evidence that the individual is likely to be male, supported by the general robusticity of the skeleton. The poor preservation of the long bones meant that stature calculations utilised the fibula only and provided an estimated stature between 163–170cm (5ft 3in–5ft 5in).

Pathological evidence was principally observed on the dentition. Linear enamel hypoplasia was observed near the occlusal surface of a 1st premolar, indicating a period of stress around the age of 3 to 4 years old. The dentition also exhibited slight evidence of periodontal disease and calculus was common. A second premolar had been almost entirely obliterated by caries, with only a discoloured root remaining. In addition, slight evidence of porotic hyperostosis (cribra orbitalia) was observed in the right orbit. The lesion was barely discernable and was largely healed by the time of death, but is suggestive of a period of nutrient deficiency in earlier life. These lesions have often been attributed to an anaemic response to iron deficiency, although some research suggests that they have a diverse aetiology (Walker *et al.* 2009). Pathology on the postcrania was confined to a probable poorly healed fracture on the radius (Fig. 12, top). This appeared to be slightly misaligned in healing and was associated with an osteomyelitic lesion. Two congential abnormalities were also observed: the absence of third molars, and the presence of the vastus notch on both patellae. These non-metric traits have a congenital aetiology and are relatively common in European populations (Kazanci *et al.* 2010; Scheuer and Black 2000, 397).

Radiocarbon dating of this individual produced a post-Roman date (cal. AD 425–545, 2 sigma). Individual 6 had a $^{87}Sr/^{86}Sr$ isotope ratio of 0.7109. This value is consistent with a range of locations throughout Britain including mid Wales, the Isle of Man, parts of the Lake District and the Scottish borders. The closest potential area of origin to Lesser Garth cave is the south Wales valleys (biosphere zone 0.711–0.712, Evans *et al.* 2010). The biogenic value would be expected to be lower than the biosphere value, as this is an area of high rainfall and therefore life signatures are altered toward the rainfall value of 0.70918. The drinking water corrected $\delta^{18}O$ value of –5.9‰ (following Daux *et al.* 2008) is also broadly consistent with a south Wales valleys origin. A value of –6.0 to –7.0‰ might be expected (see Darling *et al.* 2003) but some degree of error is normal in drinking water corrected oxygen isotope values. These values are consistent with an origin in the carboniferous areas of the south Wales coalfield, close to Lesser Garth Cave. However, plants would need to be analysed to determine the local biosphere range in order to confirm this. The other aforementioned potential areas of origin can also not be discounted.

To summarise, individual 6 is a young adult, likely male that died around the age of 25. The presence of enamel hypoplasia and cribra orbitalia suggests that he endured periods of stress during developmental years and therefore may have been malnourished or suffered infectious disease as a child. Isotope results are consistent with the individual having been raised locally.

Individual 7 (cal. AD 570–655)

Individual 7 is the most complete individual recovered during the 1912–13 excavations, comprising a total of 58 specimens. The skeleton comprises both tibiae, fibulae, parts of both mandibles, a radius and ulna, a distal humerus, part of the frontal and a range of bones of the extremities, spine and thorax.

Almost all bones exhibited evidence of post-depositional fragmentation. Modifications indicative of sub-aerial exposure (e.g. weathering, gnawing, water abrasion) were also observed, demonstrating a complex taphonomic history. Blue/green staining was evident on ten elements, which is consistent with the presence of copper (particularly on the hands and arms). Green staining on the distal ends of metacarpals and a phalanx suggest that copper alloy object(s) were present near the hands, but these may not have been deposited in association. Further staining was recorded on the radius (Fig. 12, bottom), ulna, three vertebrae and a rib. Staining resulting from taphonomic processes unrelated to the deposition of metalwork cannot be entirely discounted as the cause.

Evidence for age determination is limited but four mandibular teeth have wear patterns characteristic of a young adult aged between 17 and 25. This is supported by the relatively open cranial sutures and the lack of evidence for degenerative disease. Epiphyseal fusion indicates that the individual was at least 16 years old, as the proximal tibia and fibula were fused. All landmarks present on the cranium and mandible indicated that the individual was female. This is supported by the gracile character of the postcranial skeleton and the small estimated stature of 155–162cm (5ft 0in–5ft 3in), based on fibula measurements.

Dental pathology was rife in spite of only four mandibular teeth being present. The surviving tooth row exhibited moderate periodontal disease and calculus and three of the four teeth were affected by caries. One lesion was very severe and would have made mastication very painful. On the postcrania, a healed fracture was present on one rib, as was a very minor Schmorl's node on the sacrum. One non-pathological trait was observed, a pronounced septal aperture on the right humerus. This trait has generally been thought to have a genetic aetiology, although work by Mays (2008) tentatively suggests that it may be an indication of hypermobility. This individual was dated to the early medieval period (cal. AD 570–655, 2 sigma).

$^{87}Sr/^{86}Sr$ isotope analysis of individual 7 provided a value of 0.7120. Given the effect of rainfall on biogenic strontium isotope ratios, the individual is likely to derive from more radiogenic geology than individual 6, probably from the biosphere zone of 0.712–0.713 (see Evans *et al.* 2010). The closest plausible origins would be in the Devonian Old Red Sandstone deposits extending from the north-east of Cardiff into the Black Mountains in south-east Wales, though not in the immediate locality of the cave. However, more comprehensive biosphere mapping would be required to confirm this. The drinking water corrected $\delta^{18}O$ isotope value of –6.08‰ is also consistent with this region (see Darling *et al.* 2003). This provides the most likely origin given its proximity, but other possible areas (e.g. Pembrokeshire, north Devon, Scottish borders) exist.

To summarise, individual 7 is a slightly built young adult female. She exhibited no evidence for nutrient deficiency or dietary stress (e.g. cribra orbitalia, enamel hypoplasia) but had very poor dental health and showed partial copper staining on some bones, particularly from both hands. Isotope evidence suggests that the individual may have been raised in south-east Wales, though not in the immediate vicinity of the cave.

Isotope analysis of diet

Isotope results are summarised in Table 3. For $\delta^{13}C/\delta^{15}N$ isotope analysis only very general comments can be made about the diet of the five individuals based on this very small sample and in the absence of any baseline data from local plants and animals. Therefore, results are not described under the heading of each individual. Isotope values are well within the expected range for post-Mesolithic humans. $\delta^{13}C$ values show relatively little variation between the different samples. All are consistent with diets dominated by terrestrial foods and marine resources can only have made a negligible contribution. $\delta^{15}N$ values indicate a substantial animal protein (meat/dairy) contribution to the diet of all individuals. Individuals 1 and 3 have slightly lower values than the other samples and therefore may have been more reliant on plant foods.

DISCUSSION

The radiocarbon dating programme was initiated in response to the published view that the human remains were likely to be prehistoric or Romano-British. The Middle Bronze Age pottery with its Trevisker affinities, like the pottery from Culver Hole Cave (Quinnell 2012, 165), as well as affinities to the Biconical Urn and Deverel-Rimbury traditions was of particular interest as cremation is normal in this period. Confirmation that the human remains are not Bronze Age in date points to activities at this period in the cave as a special place, neither funerary nor completely domestic.

In this light, the results of the radiocarbon dating programme were particularly interesting. None of the dates of the five individuals are prehistoric or Romano-British, as originally surmised, and no dates overlap. The calibrated radiocarbon dates indicate that the cave became a final resting place for human remains (by whatever means) from the post-Roman to the post-medieval periods. As stated above, artefacts recovered from the cave ranged in date from the Neolithic to the post-medieval period, but there had been a suspicion that the human remains may have represented a distinct practice at a certain time in the cave's use. It was formerly considered likely that the remains would be either prehistoric or Romano-British, as numerous caves in Wales have evidence of the deposition of human remains during these periods (see Chamberlain and Williams 2000). The only other known published early medieval example is an unstratified human femur from Cefn Cave, Denbighshire (OxA-6234: 1445±60 BP (one sigma), cal. AD 430–675 (two sigma); National Museum Archive; Aldhouse-Green 2012, 344). Only one cave, Minchin Hole, has yielded both human remains and early medieval artefacts (ibid.). Therefore, the presence in Lesser Garth Cave of at least three individuals from the early medieval period is significant. The thirteenth-century human remains appear to be the first confirmed medieval instances from a cave in Wales.

As discussed in the introductory sections of this report, reconstructing distinct individuals from disarticulated remains with very little contextual information is highly problematic. If the different excavations are considered discrete, a minimum of seven individuals are present, but if bones are amalgamated this reduces to five. However, as articulating remains were relatively rare and many specimens have been assigned on the basis of morphology and robusticity, these figures by no means represent an absolute number and it is possible that several more individuals are present, but represented by very few elements.

Two of the dated early medieval individuals (3 and 7) and one medieval individual (1) had evidence for copper staining on some bones. The pattern of this green staining was checked to determine whether any might relate to dress accessories which may originally have been worn by the individuals concerned. The stain on the phalanx of individual 1 is consistent with the wearing of a bronze finger-ring, though no diagnostic late thirteenth-century rings were recovered. The only contender is a large bronze ring with a circular cross-section published by Hussey (1966, fig. 5, no. 9) which is probably a suspension ring. Could the pattern of staining at the distal ends of the ulna and radius and on the metacarpals of early medieval individual 7 be derived from a bracelet? The pattern differs considerably from the staining pattern created by a bracelet worn by a man buried in the Carmelite Friary at Aberdeen between about 1350 and 1560 (Gilchrist and Sloane 2005, fig. 60). The location of staining on metacarpals, vertebrae, a rib and a phalanx from individual 7 point to unrelated objects as possible sources. The green stained humerus of individual 3 (cal. AD 880–1000) could also, in theory, reflect the position of associated dress fastenings. The brooch-pin from the cave, probably found in the small level space near the entrance (first chamber), was a functioning dress accessory. In considering whether it could have been associated with any of the human remains, or lost by another person, dates, likely circulation rate, and context are critical. It has been established above that the brooch-pin was probably modified in its final form in the late eighth or early ninth century. It resembles a ringed pin, but lacks the cast strength of their rings. Ringed pins were usually worn on the shoulder, though they could be displaced or not used in a conventional manner in formal burial, as appears to be the case in the Viking graves at Cumwhitton (Paterson *et al.* 2014, fig. 70). When ringed pins occur against the midriff they have been thought to indicate use to secure cloaks in position when individuals were buried (Fanning 1994, 125–7; Paterson *et al.* 2014, 80). In view of the slightly later radiocarbon date range and degree of wear on the back of the 'brooch' element, there is no direct confirmation that individual 3 may have worn this diagnostic accessory.

As the dated number of early medieval individuals is only three, and none of the dates overlap (having date ranges that span four centuries), the cave was either used for the deposition of the dead in only exceptional circumstances, or the evidence for each individual should be interpreted in isolation as the result of a range of possible events, accidental or pre-determined, none necessarily connected. The fact that four individuals are represented by no more than three bones each raises the question of whether more human bone awaits discovery, and also raises the possibility that some bone entered the cave as a result of carnivore scavenging (although gnawing evidence was scarce).

Early medieval cave use

What can we infer about cave use? The lack of context, degree of disturbance and heavy fragmentation substantially reduces the interpretative potential of the remains. The mixing and fragmentation of the remains is almost certain to result from the complex taphonomic trajectories which affect cave deposits and there is no evidence to suggest that this resulted from deliberate human activity. Subsequent human activity including techniques employed in previous excavations are also likely to have impacted on preservation and mixing, particularly as Hussey used explosives in his 1964–66 excavations. It is therefore likely that all individuals were buried in a fully articulated state. No particularly unusual pathological alterations were observed and the combination of dental pathologies (caries, linear enamel hypoplasia, periodontal disease and calculus) and degenerative disease (Schmorl's nodes and osteoarthritis) are entirely typical of post-Mesolithic inhumation burials.

The new data reinforces the view that human activity at Lesser Garth changed over time—a characteristic noted at many cave sites. Human activities in caves have changed over time, as illustrated at La Garma in Spain, with information relating to the evolution of the relationship between caves and humans from 175,000 years ago up to the seventh and eighth centuries AD (Arias and Ontañón 2012, 101–15). Caves in western Britain and Ireland are similarly associated with a wide variety of early medieval activities, recognisable either through the mirror of annals and saints lives, or the evidence of the archaeological record. One well known association is with ascetic monks, for example Samson retired to a wilderness and lived in a 'spacious and very lonely' cave in a forest near the Severn (*Vita Samsonis* 42; Taylor 1925; Rose 2001, 112; Ahronson and Charles-Edwards 2010, 458), and St Illtud fled to a cave near the river Ewenni (*Vita Sancti Iltudi*, 18; Wade-Evans 1944, 221; Rose 2001, 112). Attention has been drawn to the need to place cave sites with early medieval assemblages within their early Christian landscapes, as demystified places (e.g. Ahronson *et al.* 2006, 123; Ahronson and Charles-Edwards 2010, 61). Little Hoyle Cave, beneath the early medieval settlement of Longbury Bank, has a crudely carved equal-arm cross cut into its wall, of uncertain date (a cast of which was made by the National Museum during its 1987 fieldwork programme at the cave).[19] If early medieval, it might have marked the cave as a holy space, perhaps offering protection, but the balance of evidence has been interpreted in favour of a modern date—perhaps cut by workmen during the examination of the cave by Professor Rolleston, General Pitt Rivers and others in 1878 to sanctify a place where the human remains of between nine and eleven individuals had been found (Green 1986, 101; Campbell and Lane 1993, 64). The models developed by Branigan and Dearne for cave use in Roman Britain are of relevance to subsequent periods (Branigan and Dearne 1991; 1992)—in temporal terms, cave use was seen as either 'permanent' or 'episodic', and functions could be classified according to domestic occupation, workshop activity, use as stores, provision of shelter, hideaways, places of penance and solitude, shrines or places of burial (either in a secluded location, or within the deeper recesses of the cave).

Like Lesser Garth Cave, early medieval activity has been noted at Minchin Hole Cave, excavated between 1946 and 1959. Four hearths were thought to have been used mainly in the later third to early fifth century, dating evidence taking the form of a Roman coin series running from Antoninus Pius (AD 138–61) to Gratian (AD 367–83). Early medieval coins included a denier of Lothar I (AD 840–55), a denier of Charles the Bald (AD 840–77, deposited after AD 850) and a penny of Ecgberht of Wessex by moneyer Biorhood (AD 830–39; Boon 1993, 44). In addition to Roman pottery, worked bone and metalwork, artefacts included a single-sided composite comb of late ninth- or tenth-century type, fastened with bone pegs (Branigan *et al.* 1993, fig. 5). Two fragments of human cranium were thought to be associated with Neolithic and Bronze Age flints, though these are missing and certainty on date is not possible (ibid. 63). The excavators saw nothing 'clandestine' in the nature of the late Roman occupation, perhaps by one or more family groups as a possible seasonal dwelling associated with domestic and marginal commercial activity (ibid. 71). Little was said of the early medieval activity, but the coins and comb point clearly indicate human presence for a short period during the mid/late ninth century, at about the time of the first Viking raids on north-west Wales. Bacon Hole Cave adjoins Minchin Hole Cave, and Savory records being informed of the discovery in about 1955 of a 'bronze penannular brooch of Irish seventh-century type with expanded terminals, together with beads said to be of Saxon type' from Bacon Hole Cave (Savory 1956, 55, n. 100).

Scatters of early medieval artefacts associated with everyday secular activities have been recorded at a number of Irish caves. Artefacts include those from the Inner Chamber at Kilgreany, Co. Waterford (including the top half of a baluster-headed ringed pin, part of a bell-shrine crest, spindle whorls, two rotary quernstones and whetstones: Dowd 2002, 87–8), the outer chamber of Park North, Co. Cork and Portbraddan, Co. Antrim (May 1943) and Keshcorran, Co. Sligo (including a ringed pin: Coleman 1947, 75 and fig. 2, no. 12). Early medieval domestic finds (including whetstones, spindle whorls and combs) have also been found in caves at Carrigmurrish, Co. Waterford (Coleman 1947, 70) and Park North, Co, Cork (Coleman 1942). Such evidence points to the use of these caves as shelters for short periods, or to seasonal occupation during the early medieval period.

The Irish and Welsh evidence for post-Roman cave use can be compared to the picture emerging from other northern European countries. Cave and rock shelters in Norway were used for both sacred and domestic purposes, some with evidence for short visits, others for long term occupation with thick cultural deposits. Those from central Norway show use from the Neolithic into the medieval period (Haug 2012, 39). The rock shelter 'Smiehelleren' at Monge, Møre og Romsdal, has at least four main phases, starting in the Early Bronze Age. The third phase, represented by a smithy, dates to *c*. AD 1350–1400 (Haug 2012, 46).

Caves on Iceland were occupied during the early medieval and medieval periods (e.g. Ahronson 2003, 53ff) and the thirteenth-century Landnámbok and the fourteenth-century Harðarsaga ok Hólmverja identify Surtshellir as a base for an outlaw band that fortified the cave in the tenth century (Ólafsson *et al.* 2006, 395). This is one of 33 Icelandic caves with evidence of human occupation or activity from the ninth century to the present day. Radiocarbon dates from the midden animal bone supports a late ninth- to tenth-century date, connected with the period of outlaw activity in the medieval accounts (ibid. 398).

Human remains have been found in a number of Welsh caves, though the Lesser Garth bone is the first group to be firmly dated to the post-Roman periods. Excavations by H. E. David and T. K. Penniman from 1924 at Culver Hole Cave, Llangennith, Gower, produced human remains representing at least 30 individuals from a middle clay layer, and broken human remains in an upper clay layer (David 1923–24, 25–8; Penniman 1931; 1932; 1935; Branigan and Dearne 1991, 154–5). A range of Bronze Age and Roman finds (including a figurine) were recovered, along with one incomplete copper-alloy penannular brooch with ball terminals.[20] This brooch shares affinities with silver penannular brooches with ball-shaped terminals from the Skaill hoard, Sandwick, Orkney (deposited *c*. AD 950–70; Graham-Campbell 1995, 108–27, pls 10, 11) and was considered to be a casual loss during the tenth century (Knight 1984, 351, fig. 54, 6; Penniman 1931, 90–2; Graham-Campbell 1983, fig. 136b). The human remains have been variously interpreted as probably belonging to 'the native population of the Roman period' (Savory 1984b, 215), a 'Romano-British cave cemetery' (Knight 1984, 351), and probably relating 'at least in part to a Bronze Age ossuary function' (Branigan and Dearne 1991, 155).

In the light of radiocarbon dating programmes indicating that human bones from caves in Ireland ranged in date from the early Mesolithic to the seventeenth century the *Human Remains from Irish Caves Project* was started in 2005. Its aim was to complete full osteoarchaeological analysis of human remains from 24 Irish caves (Dowd *et al.* 2006, 16). It has long been believed that Dunmore Cave, Co. Kilkenny, is *Derc Ferna*, site of the killing of local people by Dublin Vikings in AD 930, recorded in the *Annals of* *the Four Masters*, *Annals of Ulster*, *Annals of Inisfallen* and the *Chronicon Scotorum* (Dowd *et al.* 2007, 7–17). Since 1699, visitors have commented on the large quantity of human bone present in the cave. Recently, silver coins dated *c*. AD 928 (found in 1973) and a possible late tenth-century hoard (found in 1999) which included 16 silver wire cones, hack-silver, a silver penannular arm-ring, strap tags and 14 Anglo-Saxon silver pennies were excavated from Dunmore Cave, Co. Kilkenny (Drew and Huddart 1980, 17; Wallace and Ó Floinn 2002, 223; Dowd *et al.* 2007, 7). Subsequent excavations in 2004–05 produced two copper alloy ringed pins, a blue glass bead and fragment of shale/lignite bracelet, six foil covered glass beads and 351 human bones. Not all the human bone recovered over the centuries was available for study, but the collection examined produced a minimum number of 18 adults and 25 juveniles, none displaying evidence of violent trauma. Four human bones were radiocarbon dated, from a 6 to 7 year old child (cal. AD 892–1013), and 11 to 16 year old child (cal. AD 892–1013), a 1 to 2 year old child (cal. AD 779–973) and an adult (cal. AD 779–973), the two clusters appearing to reflect the two hoard dates. In the absence of trauma from the 2004–05 bones and over 2,000 from earlier excavations, an alternative to the violent massacre has recently been proposed, that the cave was a Viking burial ground similar to Cloghermore Cave, Co. Kerry, rather than the remains of a Viking massacre (Dowd *et al.* 2006, 19; Dowd *et al.* 2007, 15). The cave at Cloghermore has produced evidence for unusual early medieval burial activity, associated with eighth- to ninth-century pagan Irish activity and a late ninth- to tenth-century Viking family (Connolly and Coyne 2005). Finds included ringed pins, gaming pieces, spindle whorls and a Viking silver hoard (*c*. AD 910–40). Another cave at Cushendall, Co. Antrim, had two human skeletons ‘near the cave entrance’, and two bronze axes and two silver coins dated AD 839 were recorded as being found nearby (Coleman 1947, 77).

CONCLUSION

It has been established that the human remains from Lesser Garth Cave:

- Represent up to seven individuals, of whom five have been radiocarbon dated.
- That three are fairly complete, of whom the two of early medieval date may have lain on the cave floor and the one of medieval date was buried under the floor.
- That none of the individuals dated are prehistoric or Roman.
- That none of the individuals appear to be contemporary, the radiocarbon dates suggesting that they died in different centuries. When the number of individuals was first known the reaction was that they were likely to be linked in time and culture. That this was not the case shows the importance of radiocarbon dating when human remains are not found in a dateable context.
- That what has been previously described as a ring pin is in fact a brooch-pin in a second phase of life, probably being converted from a penannular brooch pin in the early ninth century. Individual 3, only represented by one bone, was radiocarbon dated to cal. AD 881–998. For the brooch-pin to have been associated with this individual, it would have needed to have remained in use until at least the last quarter of the ninth century, by which time the brooch-pin was being overtaken in popularity by the ringed pin.
- That the earlier view that the brooch-pin and the iron slotted pointed tool represented a possible Irish connection can be revised. The former object may not have been made in Ireland and the latter object type is no longer considered culturally specific. As isotope analysis of individuals 6 and 7 (early medieval) suggests that they were raised locally there is no obvious evidence of a link with Ireland.

- That confirmation that the human remains are not Bronze Age in date suggests that activities took place in the cave as a special place at this period, but the context was neither funerary nor completely domestic.

It has not been possible to establish a direct association between the early medieval and medieval artefacts from the cave with the human remains, nor could the cause of death be determined for any of the individuals. Accordingly, one can only speculate as to why the remains of these individuals ended up in the Lesser Garth Cave. As described above, each individual is separated from the others in time, and each deposition should be considered as an isolated event, at different periods of activity. A similar pattern was noted in the *Human Remains from Irish Caves Project*, where small numbers of bones were noted from the majority of caves, only four producing evidence for deliberate deposition of burial. Virtually none of the human bones from the 24 sites investigated displayed evidence for interference from animals, such as gnaw marks, and it seemed that in most cases human cadavers or clusters of bones were placed directly on the cave floors, and were not buried (Dowd *et al.* 2006, 17). As John Ward surmised for Lesser Garth, Dowd *et al.* (2006, 17) have suggested that the cave entrances may have been temporarily blocked to prevent animals entering and scavenging the remains. It can be argued that of the more complete Lesser Garth individuals (1, 6 and 7), medieval individual 1 was buried under the cave floor, and early medieval individuals 6 and 7 were laid on the surface of the cave floor, such as it was, until disturbed by rock falls and intrusive activities.

It is possible that some of the individuals found at Lesser Garth were on the fringe of society and that this may explain why they were not given the customary Christian burial rite. As the cave is secluded, murder, vagrancy and suicide may have played a part. The child (individual 5) could represent an unrecorded accidental death in the seventeenth century, resulting from misadventure. In spite of the lack of contextual information and an inability at present to provide answers, the evidence from the cave continues to reveal more information, and the human remains make a valuable addition to the limited corpus of post-Roman human cave burials from Wales.

It will be interesting to know whether fieldwork in the Wye Valley Gorge Caves Survey at Symonds Yat, Forest of Dean, undertaken by Herefordshire Archaeology in partnership with Forestry Commission (systematic survey of caves, rock shelters and mines on western bank of the Wye, Herefordshire) provides further parallels to the evidence from Lesser Garth (a seventh-century date has been suggested for human remains; Hoverd 2012, 4).

Branigan and Dearne acknowledged the difficulties in assessing human bone from caves producing clear artefactual evidence for Roman activity. In light of the various claims over the date of human remains from Culver Hole Cave, undated remains of about six individuals including children reported from Maeshafn Cave in north-east Wales (Branigan and Dearne 1991, 165–6), the remains of at least 40 individuals from Ogof-yr-esgryn, Powys (Branigan and Dearne 1991, 176–7; Branigan and Dearne 1992, 35) and the general disassociation of the human remains from Lesser Garth with most of the activities indicated by artefacts from the cave, further dating of human remains from caves remains a priority for future research.

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NOTES

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5. NMW, acc. no. 43.193,
6. 'Cave of Little Garth, Dec. 28. 1913'; National Museum archive, NMW acc. no. 20.359.
7. NMW acc. no. 64.135.
8. Note by Ward, fos 1–2; NMW archive.
9. NMW acc. no. 64.135/20.
10. 46.3g; NMW acc. no. 64.135/10.
11. 24.4 × 24.6mm; 25.6 × 24.5mm; NMW acc. no. 64.135/8.
12. 162mm long and 1.3–2mm thick; NMW acc. no. 20.359/7.
13. 16.6 × 19.7mm and 13 × 30mm; NMW acc. no. 64.135/1, 2.
14. NMW acc. no. 64.135/11.
15. NMW acc. no. 64.135/9.
16. Inner diameter of wrap around hoop 5.6 × 7.2mm; NMW acc. no. 35.119.
17. NMW acc. no. 36.175.
18. NMW acc. no. 31.118; analysis by P. Northover.
19. NMW acc. no. 87.70H.
20. NMW acc. no. 31.118/2.

BIBLIOGRAPHY

Ahronson, K., 2003. 'One North Atlantic cave settlement: preliminary archaeological and environmental investigations at Seljaland, southern Iceland', in K. Ahronson (ed.), 'Atlantic Peoples between Fire, Ice, River and Sea: Past Environments in Southern Iceland', special issues, *Northern Studies* 37, 53–70.

Ahronson, K. and Charles-Edwards, T. M., 2010. 'Prehistoric annals and early medieval monasticism: Daniel Wilson, James Young Simpson and their cave sites', *Antiquaries Journal* 90, 455–66.

Ahronson, K., Gillies, W. and Hunter, F., 2006. 'Early Christian activity at Scottish cave sites', *Church Archaeology* 7–9, 123–5.

Alcock, L., 1959. 'Dark Age objects of Irish origin from Lesser Garth Cave', *Bulletin of the Board of Celtic Studies* 18, 221–7.

Aldhouse-Green, S., 2012. 'The Pontnewydd people, their cave and their world', in S. Aldhouse-Green, R. Peterson and Elizabeth A. Walker (eds), *Neanderthals in Wales. Pontnewydd and the Elwy Valley Caves* (Oxford: Oxbow Books), 327–44.

Ambrose, S. H., 1993. 'Isotopic analysis and paleodiets: methodological and interpretative considerations', in M. K. Sandford (ed.), *Investigation of Ancient Human Tissue: Chemical Analyses in Anthropology* (Langhhorne: Gordon and Breach Science Publishers), 59–130.

Arias, P. and Ontañón, R., 2012. 'La Garma (Spain): long-term human activity in a Karst system', in Bergsvik and Skeates 2012, 101–17.

Bergsvik, K. A. and Skeates, R. (eds), 2012. *Cave in Context. The Cultural Significance of Caves and Rockshelters in Europe* (Oxford: Oxbow Books).

Birck, J. L., 1986. 'Precision K-Rb-Sr isotopic analysis: application to Rb-Sr chronology', *Chemical Geology* 56, 73–83.

Boon, G. C., 1967. 'The coins', in G. J. Wainwright, *Coygan Camp. A Prehistoric, Romano-British and Dark Age Settlement in Carmarthenshire* (Carmarthen: Cambrian Archaeological Association), 110–26.

——1972. 'Romano-British counterfeiters on Mendip and in South Wales: two deposits and a discussion', *Proceedings of the University of Bristol Spelaeological Society* 13 (i), 70–82.

——1993. 'The coins', in K. Branigan, M. J. Deare and J. G. Rutter, 'Romano-British occupation of Minchin Hole Cave, Gower', *Archaeologia Cambrensis* 142, 40–73.

Branigan, K. and Dearne, M. J. (eds), 1991. *A Gazetteer of Romano-British Cave Sites and their Finds* (Sheffield: University of Sheffield).

—— (eds) 1992. *Romano-British Cavemen: Cave Use in Roman Britain*. Oxbow Monograph 19 (Oxford: Oxbow Books).

Branigan, K., Dearne, M. J. and Rutter, R. G., 1993. 'Romano-British occupation of Minchin Hole Cave, Gower', *Archaeologia Cambrensis* 142, 40–73.

Brooks, S. and Suchey, J. M., 1990. 'Skeletal age determination based on the os pubis: a comparison of the Acsádie Nemeskéri and Suchey Brooks methods', *Human Evolution* 5, 227–38.

Brothwell, D. R., 1981. *Digging up Bones* (New York: Cornell University Press).

Buikstra, J. and Uberlaker, D., 1994. *Standards for Data Collection from Human Skeletal Remains* (Fayetteville: Arkansas Archaeological Survey).

Campbell, E., 1988. 'Lesser Garth Cave', in N. Edwards and A. Lane (eds), *Early Medieval Settlements in Wales AD 400–1100* (Bangor and Cardiff: Early Medieval Wales Archaeology Research Group), 86–7.

——1998, 'Miscellaneous ironwork' and 'Metalworking debris', in N. Sharples, *Excavations at Scalloway, Shetland* (Oxbow, Oxford), 159–64.

Campbell, E. and Lane, A., 1993. 'Excavations at Longbury Bank, Dyfed, and early medieval settlement in South Wales', *Medieval Archaeology* 37, 15–77.

Chamberlain, A. T. and Williams, J., 2000. *Gazetteer of Welsh Caves, Fissures and Rock Shelters containing human remains, Capra* 2 (Sheffield), available at <http://capra.group.shef.ac.uk/2/wales.html>.

Chapman, E., 2005. *A Catalogue of Roman Military Equipment in the National Museum of Wales*, British Archaeological Reports, British Series 388 (Oxford).

Coleman, J. C., 1942. 'Cave excavation at Midleton, Co. Cork', *Journal of the Cork Historical and Archaeological Society* 47, 63–76.

——1947. 'Irish cave excavation', *Journal of the Royal Society of Antiquaries of Ireland* 77, 63–80.

Connolly, M. and Coyne, F., 2005. *Underworld: Death and Burial at Cloghermore Cave, Co. Kerry* (Bray: Wordwell).

Coplen, T. B., 1988. 'Normalization of oxygen and hydrogen isotope data', *Chemical Geology* 72, 293.

Cotter, C., 1999. 'Cahercomaun Fort, Co. Clare: a reassessment of its cultural context', *Discovery Programme Report* 5, 41–95.

Darling, W. G., Bath, A. H. and Talbot, J. C., 2003. 'The O & H stable isotopic composition of fresh waters in the British Isles: 2, surface and ground waters', *Hydrology and Earth System Sciences* 7, 183–95.

Daux, V., Lécuyer, C., Héran, M. A., Amiot, R., Simon, L., Fourel, F., Martineau, F., Lynnerup, N., Reychler, H. and Escarguel, G., 2008. 'Oxygen isotope fractionation between human phosphate and water revisited', *Journal of Human Evolution* 55, 1138–47.

David, H. E., 1923–24. 'Culver Hole', *Report for the Royal Institute of South Wales*, 25–8.

Dowd, M., 2002. 'Kilgreany, Co. Waterford: biography of a cave', *Journal of Irish Archaeology* 11, 77–97.

Dowd, M., Fibiger, L. and Lynch, L. G., 2006. 'The human remains from Irish caves project', *Archaeology Ireland* 20 (3), 16–19.

Dowd, M. A., Lynch, L. G. and McCarthy, M., 2007. 'Recent archaeological discoveries in Dunmore Cave, County Kilkenny: further questions regarding Viking activity at the site', *Old Kilkenny Review* 59, 7–17.

Drew, D. P. and Huddart, D., 1980. 'Dunmore Cave, County Kilkenny: a reassessment', *Proceedings of the Royal Irish Academy* 80B, 1–23.

Eogan, G., 1991. 'Irish Antiquities of the Bronze Age, Iron Age and Early Christian period in the National Museum of Denmark', *Proceedings of the Royal Irish Academy* 91C, 6, 133–76.

Evans, J. A., Montgomery, J., Wildman, G. and Boulton, N., 2010. 'Spatial variations in biosphere $^{87}Sr/^{86}Sr$ in Britain', *Journal of the Geological Society* 167, 1–4.

Fanning, T., 1994. *Viking-age Ringed Pins from Dublin* (Dublin: Royal Irish Academy).

Gilchrist, R. and Sloane, B., 2005. *Requiem. The Medieval Monastic Cemetery in Britain* (London: Museum of London Archaeological Service).

Goodall, I. H., 1980. 'The iron objects', in P. Wade-Martins, *Excavations in North Elmham Park 1967–72*, East Anglian Archaeology Report No. 9 (Gressenhall), 509–16.

Graham-Campbell, J., 1983. 'Some Viking-age penannular brooches from Scotland and the origins of the 'Thistle-Brooch' ', in A. O'Connor and D. V. Clarke (eds), *From the Stone Age to the 'Forty-Five'* (Edinburgh: J. Donald), 310–23.

——1995. *The Viking-Age Gold and Silver of Scotland (AD 850–1100)* (Edinburgh, National Museums of Scotland).

Green, S., 1986. 'Excavations at Little Hoyle (Longbury Bank), Wales, in 1984', in D. A. Roe (ed.), *Studies in the Upper Palaeolithic of Britain and North-West Europe*, British Archaeological Reports, International Series 296, 99–119.

Harrison, S. H. and Ó Floinn, R., 2014. *Viking Graves and Grave-Goods in Ireland. Medieval Dublin Excavations 1962–81*, Ser. B, vol. 11 (Dublin).

Haug, A., 2012. 'Chapter 4. Rockshelters in central Norway: Long-term changes in use, social organization and production', in Bergsvik and Skeates 2012, 39–47.

Hencken, H. O'Neill, 1938. 'Cahercommaun: a stone fort in County Clare', *Royal Society of Antiquaries of Ireland Extra volume for 1938* (Dublin).

——1950. 'Lagore Crannog: an Irish royal residence of the 7th to 10th centuries AD', *Proceedings of the Royal Irish Academy* 53, 1–247.

Hinton, D. A., 1996. *The Gold, Silver and Other Non-ferrous Alloy Objects from Hamwic*, Southampton Finds volume 2 (Stroud: Sutton).

Hoverd, T., 2012. 'Wye Valley caves survey', *Historic Environment Today. Herefordshire Council Historic Environment Newsletter* 15.1, 3–4.

Hussey, M. S., 1966. 'Final excavations at the Lesser Garth Cave, Pentyrch', *Transactions of the Cardiff Naturalists Society* 93, 18–39.

Katzenberg, M. A., 2000. 'Stable isotope analysis. A tool for studying past diet, demography and life history', in M. A. Katzenberg and S. R. Saunders (eds), *Biological Anthropology of the Human Skeleton* (New York: Wiley Liss), 305–27.

Kazanci, F., Celikoglu, M., Miloglu, O. and Oktay, H., 2010. 'Third molar agenesis among patients from the East Anatolian region of Turkey', *Journal of Contemporary Dental Practice* 11, 33–40.

Knight, J. K., 1984. 'Glamorgan A.D. 400–1100: Archaeology and History', in Savory 1984a (ed.), 315–64.

Lewis, J. M., 1982. 'Recent finds of penannular brooches from Wales', *Medieval Archaeology* 26, 151–4.

Lovejoy, C., Meindl, R. S., Pryzbeck, T. R. and Mensforth, R. P., 1985. 'Chronological metamorphosis of the auricular surface of the ilium: a new method for the determination of adult skeletal age', *American Journal of Physical Anthropology* 68, 15–28.

May, A. M., 1943. 'Portbraddan Cave, County Antrim', *Ulster Journal of Archaeology* 6, 39–60.

Mays, S., 1998. *The Archaeology of Human Bones* (London: Routledge).

——2008. 'Septal aperture of the humerus in a mediaeval human skeletal population', *American Journal of Physical Anthropology* 136, 432–40.

Montgomery, J., 2010. 'Passports from the past: investigating human dispersals using strontium isotope analysis of tooth enamel', *Annals of Human Biology* 37, 325–46.

Meaney, A. L. and Hawkes, S. C., 1970. *Two Anglo-Saxon Cemeteries at Winnall, Winchester, Hampshire*, Society for Medieval Archaeology Monograph 4.

Ólafsson, G., McGovern, T. H. and Smith, K. P., 2006. 'Outlaws of Surtshellir Cave – the underground economy of Viking Age Iceland', in J. Arneborg and B. Grønnow, *Dynamics of Northern Societies. Proceedings of the SILA/NABO Conference on Arctic and North Atlantic Archaeology, Copenhagen, May 10th–4th, 2004*, Publications from the National Museum Studies in Archaeology & History 10 (Copenhagen), 395–405.

Ó Ríordain, S. P., 1949, 'Lough Gur Excavations: Carrig Aille and the "Spectacles" ', *Proceedings of the Royal Irish Academy* 52c (1948–50), 39–111.

Ottaway, P., 2009. 'Miscellaneous iron fixtures and fittings', in D. H. Evans and C. Loveluck (eds), *Life and Economy at Early Medieval Flixborough c. AD 600–1000. The Artefact Evidence*, Excavations at Flixborough vol. 2 (Oxford: Oxbow), 203–31.

Paterson, C., Parsons, A. J., Newman, R. M., Johnson, N., Davis, C. H., 2014. *Shadow in the Sand. Excavation of a Viking-age Cemetery at Cumwhitton, Cumbria*, Lancaster Imprint 22 (Lancaster).

Peng, B., Wu, W., Hou, S., Shang, W., Wang, X. and Yang, Y., 2003. 'The pathogenesis of Schmorl's nodes', *Bone and Joint Journal* 85, 879–82.

Penniman, T. K., 1931. 'Culver Hole Cave, Llangennith, Gower', *Bulletin of the Board of Celtic Studies* 6, 90–2.

——1932. 'Culver Hole Cave and vicinity, Llangennith and Llanmadoc, Gower', *Bulletin of the Board of Celtic Studies* 6, 196–200.

——1935. 'Culver Hole Cave, Llangennith and vicinity', *Bulletin of the Board of Celtic Studies* 7, 417–18.

Perizonius, W. R. K., 1984. 'Closing and non-closing sutures in 256 crania of known age and sex from Amsterdam', *Journal of Human Evolution* 13, 201–16.

Petersen, J., 1940. *Viking Antiquities in Great Britain and Ireland Part V. British Antiquities of the Viking Period, found in Norway* (Oslo: H. Aschehoug).

Quinnell, H., 2012. 'Trevisker Pottery: some recent studies', in W. J. Britnell and R. J. Silvester (eds), *Reflections on the Past. Essays in honour of Frances Lynch* (Welshpool: Cambrian Archaeological Association), 146–71.

RCAHMW, 1976. *An Inventory of the Ancient Monuments in Glamorgan Volume I: Pre-Norman, Part I. The Stone and Bronze Ages*, Royal Commission on the Ancient and Historical Monuments of Wales (Cardiff: HMSO).

Redknap, M., 1991. *The Christian Celts. Treasures of Late Celtic Wales* (Cardiff: National Museum of Wales).

——forthcoming. 'Early medieval ironwork', in A. Lane and M. Redknap, *The Royal Crannog at Llangorse. The Investigation of an Early Medieval Island residence of the Kings of Brycheiniog*.

Redknap, M., Madgwick, R., Davies, B., Gwilt, A. and Cox, M., 2008. 'The Lesser Garth Cave human remains', *Archaeology in Wales* 48, 75–7.

Reimer, P. J., Bard, E., Bayliss, A., Beck, J. W., Blackwell, P. G., Bronk Ramsey, C., Buck, C. E., Cheng, H., Edwards, R. L., Friedrich, M., Grootes, P. M., Guilderson, T. P., Haflidason, H., Hajdas, I., Hatté, C., Heaton, T. J., Hogg, A. G., Hughen, K. A., Kaiser, K. F., Kromer, B., Manning, S. W., Niu, M., Reimer, R. W., Richards, D. A., Scott, E. M., Southon, J. R., Turney, C. S. M. and van der Plicht, J., 2013. 'IntCal13 and MARINE13 radiocarbon age calibration curves 0–50000 years cal BP', *Radiocarbon* 55, 1869–87.

Rose, P., 2001. 'Shadows in the imagination: encounters with caves in Cornwall', *Cornish Archaeology* 39–40, 95–128.

Savory, H. N., 1956. 'Some sub-Romano-British brooches from South Wales', in D. B. Harden (ed.), *Dark-Age Britain: Studies presented to E. T. Leeds* (London: Methuen), 40–58.

——1976. *Guide Catalogue to the Iron Age Collections* (Cardiff: National Museum of Wales).

——1980. *Guide Catalogue to the Bronze Age Collections* (Cardiff: National Museum of Wales).

——1984a (ed.), *Glamorgan County History Volume II. Early Glamorgan. Pre-History and Early History* (Cardiff).

——1984b. 'The later Bronze Age in Glamorgan (c. 1450–500 B.C.)', in Savory 1984a (ed.), 201–36.

Scheuer, J. L. and Black, S., 2000. *Developmental Juvenile Osteology* (London: Academic Press).

Smith, B. H., 1991. 'Standards of human tooth formation and dental age assessment', in M. A. Kelley and C. S. Larsen (eds), *Advances in Dental Anthropology* (New York: Wiley-Liss), 143–68.

Stuiver, M. and Reimer, P. J., 1993. 'Extended ^{14}C data base and revised CALIB 3.0 ^{14}C age calibration program', *Radiocarbon* 35, 215–30.

Taylor, T. (ed. and trans.), 1925. *The Life of St Samson of Dol* (London: SPCK).

Thomas, I. A., 2014. *Quarrying Industry in Wales – A History* (Wirksworth: National Stone Centre).

Trotter, M. and Gleser, G. C., 1952. 'Estimation of stature from long bones of American whites and negroes', *American Journal of Physical Anthropology* 10, 463–514.

——1958. 'A re-evaluation of estimation of stature based on measurements of stature taken during life and of long bones after death', *American Journal of Physical Anthropology* 16, 79–123.

——1977. 'Corrigenda to "estimation of stature from long limb bones of American Whites and Negroes" ', *American Journal of Physical Anthropology* 47, 355–6.

Wade-Evans, A. W. (ed. and trans.), 1944. *Vitae Sanctorum Britanniae et Genealogiae* (Cardiff: University of Wales Press).

Walker, P. L., Bathurst, R. R., Richman, R., Gjerdrum, T. and Andrushko, V. A., 2009. 'The causes of porotic hyperostosis and cribra orbitalia: a reappraisal of the iron-deficiency-anemia hypothesis', *American Journal of Physical Anthropology* 139, 109–25.

Wallace, P. F. and Ó Floinn, R. (eds), 2002. *Treasures of the National Museum of Ireland: Irish Antiquities* (Dublin: Gill and Macmillan).

Youngs, S., 1989. *The Work of Angels. Masterpieces of Celtic Metalwork, 6th–9th centuries AD* (London: British Museum).